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# CRS Report for Congress

# Navy DDG-1000 (DD(X)) and CG(X) Ship Acquisition Programs: Oversight Issues and Options for Congress

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# Navy DDG-1000 (DD(X)) and CG(X) Ship Acquisition Programs: Oversight Issues and Options for Congress


## Summary

The Navy is procuring a new kind of destroyer called the DDG-1000 (formerly DD(X)), and wants to procure a new kind of cruiser called the CG(X). Navy plans call for procuring 7 DDG-1000s and 19 CG(X)s between FY2007 and FY2023. The first two DDG-1000s were procured in FY2007. The Navy wants to procure the first CG(X) in FY2011 and the second in FY2013.

The Navy's FY2008 budget requests $2,802 million in procurement funding to complete the Navy's estimated procurement cost for the first two DDG-1000s, which are being split-funded (i.e., incrementally funded) across FY2007 and FY2008. The Navy's combined estimated procurement cost for the two ships is $6,370 million. The two ships received $1,010 million in FY2005 and FY2006 advance procurement funding, and $2,557 million in FY2007 procurement funding. The Navy's FY2008 budget also requests $151 million in advance procurement funding for the third DDG-1000, whose procurement cost the Navy estimates at $2,563 million.

The DDG-1000/CG(X) program raises several potential oversight issues for Congress, including the accuracy of Navy cost estimates for the program, the program's affordability and cost effectiveness, the acquisition strategy for the third and subsequent DDG-1000s, and the program's potential implications for the shipbuilding industrial base.

Potential options for Congress for the DDG-1000/CG(X) program include supporting the Navy's proposed plans or curtailing the DDG-1000 and/or CG(X) programs and pursuing lower-cost alternatives to the DDG-1000 and/or CG(X) designs.

The **House Armed Services Committee**, in its report (H.Rept. 110-146) on the FY2008 defense authorization bill (**H.R. 1585**), recommended approval of the Navy's request for FY2008 procurement funding for the DDG-1000. The report recommended increasing the Navy's FY2008 request for research and development funding for the DDG-1000 program by $9 million for work on permanent magnet motor technology.

The **Senate Armed Services Committee**, in its report (S.Rept. 110-77 of June 5, 2007) on the FY2008 defense authorization bill (**S. 1547**), recommended approval of the Navy's request for FY2008 procurement funding for the DDG-1000. The report recommended increasing the Navy's FY2008 request for research and development funding for the DDG-1000 program by $15 million, of which $9 million would be for work on a permanent magnet motor system and $6 million would be for work on wireless encryption technology for use on Navy ships.

This report will be updated as events warrant.

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## Introduction

The Navy is procuring a new kind of destroyer called the DDG-1000 (formerly DD(X)), and wants to procure a new kind of cruiser called the CG(X). Navy plans call for procuring 7 DDG-1000s and 19 CG(X)s between FY2007 and FY2023. The first two DDG-1000s were procured in FY2007. The Navy wants to procure the first CG(X) in FY2011 and the second in FY2013.

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The issue for Congress is whether to approve, modify, or reject the Navy's proposals for the DDG-1000/CG(X) program. Decisions that Congress makes on procurement of surface combatants will significantly affect future Navy capabilities, Navy funding requirements, and the U.S. defense industrial base.

## Background

### Surface Combatants in the Navy

**A Major Component of the Navy.** Surface combatants are one of four major types of Navy combat ships, along with aircraft carriers, submarines, and amphibious ships.[1] In descending order of size, surface combatants include battleships, cruisers, destroyers, frigates, corvettes (also called light frigates) and Littoral Combat Ships (LCSs), and patrol craft. The Navy no longer operates battleships. The Navy's surface combatant force in recent decades has consisted largely of cruisers, destroyers, and frigates. The first LCS is scheduled to enter service in 2007.

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[1] The Navy's fleet also includes mine warfare and support ships.

In recent decades, surface combatants have accounted for 30% to 40% of the Navy's battle force ships. At the end of FY2006, they accounted for about 36% (101 of 281 battle force ships).

**Roles, Missions, and Capabilities.** From World War II until the 1980s, surface combatants were viewed largely as defensive escorts for protecting other Navy surface ships and commercial cargo ships. During this period, the primary missions of surface combatants were anti-air warfare (AAW) and anti-submarine warfare (ASW), and designs for Navy surface combatant classes were determined in large part by decisions as to whether a given class should emphasize AAW, ASW, or both. Additional but more secondary surface combatant missions during this period included anti-surface warfare (ASuW) and attacking coastal land targets with guns.

The role of Navy surface combatants changed in the 1980s with the advent of three major new systems — the Tomahawk cruise missile, the vertical launch system (VLS), and the Aegis ship combat system. In the eyes of many observers, these three systems transformed surface combatants from defensive escorts back into significant offensive combatants.[2]

The capabilities of Navy surface combatants are currently being enhanced by new networking systems such as the Cooperative Engagement Capability (CEC) for air-defense operations. Networking systems like these enable surface combatants, other ships, and aircraft to share large amounts of targeting-quality data on a rapid and continuous basis, permitting them to engage in what is called network-centric warfare (NCW).[3]

In coming years, surface combatants are scheduled to take on a growing role as platforms for conducting ballistic missile defense operations.[4] The capabilities of surface combatants will also be enhanced in coming years by increased application of networking technology and by the addition of unmanned vehicles,[5] electromagnetic rail guns, directed-energy weapons such as lasers, and improved

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[2] The Tomahawk gave surface combatants an ability to attack enemy targets at ranges comparable to those achievable by carrier-based aircraft. The VLS, which is a battery of vertical missile-launch tubes countersunk into the ship's deck, permitted surface combatants to carry and launch an increased number of Tomahawks (and other missiles). The Aegis system — an integrated ship combat system that includes the sophisticated SPY-1 multifunction phased-array radar — significantly enhanced the AAW capability of surface combatants, giving them more potential for conducting operations independent of aircraft carriers.

[3] For more on CEC and naval NCW in general, see CRS Report RS20557, *Navy Network-Centric Warfare Concept: Key Programs and Issues for Congress*, by Ronald O'Rourke.

[4] For further discussion, see CRS Report RL33745, *Sea-Based Ballistic Missile Defense — Background and Issues for Congress*, by Ronald O'Rourke.

[5] For further discussion, see CRS Report RS20557, *Navy Network-Centric Warfare Concept: Key Programs and Issues for Congress*, by Ronald O'Rourke, and CRS Report RS21294, *Unmanned Vehicles for U.S. Naval Forces: Background and Issues for Congress*, by Ronald O'Rourke.

equipment for detecting and countering mines. Some of these developments are to be enabled by the application to surface combatants of integrated electric-drive propulsion technology.[6] As these developments unfold, surface combatants will likely continue to play a significant role in defending both themselves and other friendly surface ships against enemy submarines, surface ships, aircraft, and anti-ship cruise missiles.

**Service Lives.** For planning purposes, the Navy credits its cruisers and destroyers with 35-year expected service lives (ESLs), its frigates with 30-year ESLs, and its patrol craft with 20-year ESLs. In practice, however, numerous surface combatants in recent years have been decommissioned well before the end of their ESLs for various reasons, including decisions (like the one following the end of the Cold War) to reduce the size of the Navy, shifts in Navy mission requirements that made ships with certain capabilities inappropriate, and high operation and support (O&S) costs that made ships cost-ineffective compared to other approaches for performing their missions. The Navy in recent years has decommissioned numerous cruisers, destroyers, and frigates well before the end of their ESLs.

**Current Surface Combatant Force.** As of the end of FY2006, the Navy's force of larger surface combatants consisted of 99 ships in three classes:

- 22 Ticonderoga (CG-47) class cruisers;
- 49 Arleigh Burke (DDG-51) class destroyers; and
- 30 Oliver Hazard Perry (FFG-7) class frigates.

The Navy at the end of FY2006 also operated 8 Cyclone (PC-1) class patrol craft.

**The CG-47s**, which have a full load displacement of about 9,500 tons,[7] are equipped with the Aegis system and are commonly referred to as Aegis cruisers. A total of 27 were procured between FY1978 and FY1988 and entered service between 1983 and 1994. The first five were built to an earlier technical standard — they lacked VLS, for example, and consequently could fire Tomahawks, while the final 22 are equipped with a 122-tube VLS. The Navy deemed the first five to be too expensive to modernize and decommissioned in 2004-2005. The Navy plans to modernize the remaining 22 and keep them in service to age 35.[8]

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[6] For more on electric-drive technology and its application to Navy ships, see CRS Report RL30622, *Electric-Drive Propulsion for U.S. Navy Ships: Background and Issues for Congress,* by Ronald O'Rourke.

[7] Full load displacement is the weight of the ship including loads such as fuels and water. Another measure of ship size is light (i.e., empty) ship displacement, which excludes such loads. Full load displacement is the more commonly used measure in general discussions of Navy ships, but light displacement is generally more useful in estimating ship construction costs.

[8] For further discussion, see CRS Report RS22595, *Navy Aegis Cruiser and Destroyer Modernization: Background and Issues for Congress,* by Ronald O'Rourke.

**The DDG-51s**, which displace about 9,200 tons,[9] are equipped with the Aegis system and are sometimes referred to as Aegis destroyers. They are also equipped with a 90- or 96-tube VLS. The first ship was procured in FY1985, and 62 were procured through FY2005. By the end of FY2006, 49 had entered service (the first in 1991) and the remainder were in various stages of construction. The Navy plans to give these ships a mid-life modernization and operate them to age 35.[10]

**The FFG-7s**, which displace about 4,000 tons, were designed as lower-cost, lower-capability surface combatants for use in lower-threat environments. They lack both the Aegis system and VLS. A total of 51 were procured between FY1973 and FY1984 and entered service between 1977 and 1989. Twenty-one were decommissioned by the end of FY2006. The Navy plans to decommission several more over the next decade. Of the 30 FFG-7s in service at the end of FY2006, 9 were operated as Naval Reserve Force (NRF) ships with crews consisting partly of Navy reservists.

All of these ships have landing pads for operating helicopters, and all but the first 28 DDG-51s have hangars for embarking and supporting 2 helicopters.

**The PC-1s**, which displace about 330 tons, are high-speed craft that were built to support special operations forces. They have also been used by the Navy and Coast Guard for port-security operations. A total of 13 PC-1s were procured between FY1990 and FY1996 for the Navy and entered service with the Navy between 1993 and 2000. The lead ship, PC-1, was donated to the Philippine Navy and commissioned into service with that navy in March 2004. Four other ships in the class have been loaned to the U.S. Coast Guard. PC-1s in service with the U.S. Navy are classified as local defense and miscellaneous support forces and consequently are not included in the total number of battle force ships in the Navy.

## Surface Combatant Force-Structure Goal

The Navy in coming years is proposing to maintain a fleet of 313 ships, including 88 cruisers and destroyers — 7 DDG-1000s, 19 CG(X)s, and 62 DDG-51s — and 55 LCSs.[11] Under this proposal, surface combatants would account for about 46% of the total number of ships in the Navy.

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[9] This is the figure for the 29th and following ships in the class, which are referred to as the Flight IIA ships. The first 28 ships in the class, which are referred to as the Flight I and II ships, were built to a different design that lacked a helicopter hangar and have a full load displacements of about 8,900 tons. Flight IIA ships have a light ship displacement of about 6,950 tons.

[10] For further discussion, see CRS Report RS22595, *Navy Aegis Cruiser and Destroyer Modernization: Background and Issues for Congress*, by Ronald O'Rourke.

[11] For more on the proposed 313-ship fleet, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

## Surface Combatant Industrial Base

**Construction Yards.** All cruisers, destroyers, and frigates procured since FY1985 have been built at two shipyards — General Dynamics' Bath Iron Works (GD/BIW) in Bath, ME, and the Ingalls shipyard in Pascagoula, MS, that forms part of Northrop Grumman Ship Systems (NGSS).[12] Both yards have long histories of building larger surface combatants. Construction of Navy surface combatants in recent years has accounted for virtually all of GD/BIW's ship-construction work and for a significant share of Ingalls' ship-construction work.

**Overhaul and Repair Yards.** Navy surface combatants are overhauled, repaired, and modernized at GD/BIW, Northrop/Ingalls, other private-sector U.S. shipyards, and government-operated naval shipyards (NSYs).

**System Integrators and Supplier Firms.** Lockheed Martin and Raytheon are generally considered the two leading Navy surface ship radar makers and combat system integrators. Boeing is another system integrator and maker of Navy surface ship weapons and equipment. The surface combatant industrial and technological base also includes hundreds of additional firms that supply materials and components. The financial health of the supplier firms has been a matter of concern in recent years, particularly since some of them are the sole sources for what they make for Navy surface combatants.[13]

## Future Surface Combatant Program

On November 1, 2001, the Navy announced that it was replacing a destroyer-development effort called the DD-21 program, which it had initiated in 1994-1995, with a new Future Surface Combatant Program aimed at developing and acquiring a family of three new classes of surface combatants:

- **a destroyer called DD(X)** for the precision long-range strike and naval gunfire mission,

- **a cruiser called CG(X)** for the missile and air defense mission, and

- **a smaller combatant called the Littoral Combat Ship (LCS)** to counter submarines, small surface attack craft (also called "swarm boats") and mines in heavily contested littoral (near-shore) areas.

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[12] NGSS also includes the Avondale shipyard near New Orleans and a third facility at Gulfport, MS, form Northrop Grumman's Ship Systems (NGSS) division. The Navy has not procured any frigates since FY1984, when the last FFG-7 was procured.

[13] The surface combatant industrial base also includes naval architects and engineers who work for shipyards, systems integrators, supplier firms, and independent naval architectural engineering firms, as well as research and development organizations and laboratories in the Navy and at shipyards, system integrators, supplier firms, Federally Funded Research and Development Centers (FFRDCs), and universities and colleges.

On April 7, 2006, the Navy announced that it had redesignated the DD(X) program as the DDG-1000 program.[14]

**Table 1** shows planned procurement of DDG-1000s and CG(X)s through the end of the FY2008-FY2013 Future Years Defense Plan (FYDP).

**Table 1. Planned DDG-1000 and CG(X) Procurement**

| | FY07 | FY08 | FY09 | FY10 | FY11 | FY12 | FY13 |
|---|---|---|---|---|---|---|---|
| **DDG-1000** | 2[a] | 0[a] | 1 | 1 | 1 | 1 | 1 |
| **CG(X)** | | | | | 1 | | 1 |

**Source:** FY2008-FY2013 Future Years Defense Plan (FYDP).

a. Two DDG-1000s procured in FY2007 using split funding across FY2007 and FY2008.

## DDG-1000 (formerly DD(X)) Destroyer

The first two DDG-1000s were procured in FY2007. The Navy's FY2008 budget requests $2,802 million in procurement funding to complete the Navy's estimated procurement cost for the first two DDG-1000s, which are being split-funded (i.e., incrementally funded) across FY2007 and FY2008. The Navy's combined estimated procurement cost for the two ships is $6,370 million. The two ships received $1,010 million in FY2005 and FY2006 advance procurement funding, and $2,557 million in FY2007 procurement funding. The Navy's FY2008 budget also requests $151 million in advance procurement funding for the third DDG-1000, whose procurement cost the Navy estimates at $2,563 million. Section 123 of the conference report on the FY2006 defense authorization bill (H.R. 1815/P.L. 109-163), limits the cost of the fifth DDG-1000 to $2.3 billion, plus adjustments for inflation and other factors.

The DDG-1000 destroyer is effectively the successor to the Navy's previously planned DD-21 destroyer and will resemble the DD-21 in terms of mission orientation and ship design. The DDG-1000 would be a multimission ship with an emphasis on land-attack operations that reflects a desire to replace the large-caliber naval gunfire support capability that the Navy lost in 1990-1992, when it removed its four reactivated Iowa-class battleships from service.

The DDG-1000 would have a reduced-size crew (compared to the Navy's current destroyers and cruisers) of about 142 sailors so as to permit reduced operating and support (O&S) costs. The ship would incorporate a significant number of new technologies, including a wave-piercing, tumblehome hull design for reduced

[14] The Navy also confirmed in the April 7, 2006, announcement that the first ship in the class, DDG-1000, is to be named the Zumwalt, in honor of Admiral Elmo R. Zumwalt, the Chief of Naval operations from 1970 to 1974. The decision to name the first ship after Zumwalt was made by the Clinton Administration in July 2000, when the program was still called the DD-21 program. For more on Navy ship names, see CRS Report RS22478, *Navy Ship Names: Background For Congress*, by Ronald O'Rourke.

signatures, a superstructure made partly of large sections of composite materials rather than steel or aluminum, an integrated electric-drive propulsion system, a total-ship computing system for moving information about the ship, automation technologies for the reduced-sized crew, a dual-band radar, a new kind of VLS, and two copies of a 155mm gun called the Advanced Gun System (AGS).

With a full load displacement of 14,564 tons, the DDG-1000 would be roughly 50% larger than the Navy's current 9,500-ton Aegis cruisers and destroyers, and larger than any Navy destroyer or cruiser since the nuclear-powered cruiser Long Beach (CGN-9), which was procured in FY1957.

The Navy originally envisaged procuring a total of 16 to 24 DDG-1000s. Navy officials subsequently testified in February and March 2005 that they had a requirement for 8 to 12. The Navy's reported new 313-ship plan calls for a total of seven.

**Table 2** shows DDG-1000 (and CG(X)) funding through FY2013.

Since September 30, 2005, the Navy has managed the DDG-1000 program through a series of separate contracts with major DDG-1000 contractors, including NGSS, GD/BIW, Raytheon, and BAE Systems (the maker of the AGS). Under this arrangement, the Navy in effect is acting in at least some respects as the overall system integrator for the program.

Under an earlier DDG-1000 acquisition strategy approved by the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD AT&L) on February 24, 2004, the first DDG-1000 would be built by NGSS, the second would be built GD/BIW, and contracts for building the first six would be equally divided between NGSS and GD/BIW.

In February 2005, Navy officials announced that they would seek approval from USD AT&L to instead hold a one-time, winner-take-all competition between NGSS and GD/BIW to build all DDG-1000s. On April 20, 2005, the USD AT&L issued a decision memorandum stating that "at this time, I consider it premature to change the shipbuilder portion of the acquisition strategy which I approved on February 24, 2004." The memorandum agreed to a Navy proposal to separate the system-development and software-development contracts for the DDG-1000 from the detailed-design effort for the DDG-1000. The memorandum said this change "is projected to result in savings to the Department [of Defense], and helps to ensure that all shipbuilder acquisition strategy options are preserved."

Several Members of Congress expressed opposition to Navy's proposal for a winner-take-all competition. Congress included a provision (Section 1019) in the Emergency Supplemental Appropriations Act for 2005 (H.R. 1268/P.L. 109-13 of May 11, 2005) prohibiting a winner-take-all competition. The provision effectively required the participation of at least one additional shipyard in the program but did not specify the share of the program that is to go to the additional shipyard.

## Table 2. DDG-1000/CG(X) Program Funding, FY2002-FY2013

(millions of then-year dollars, rounded to nearest million)

| | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | Total thru FY13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Research, Development, Test and Evaluation, Navy (RDTEN) account** | | | | | | | | | | | | | |
| DDG-1000[a] | 490 | 895 | 1002 | 1120 | 1041 | 788 | 503 | 426 | 500 | 555 | 320 | 174 | 7814 |
| CG(X)[b] | 0 | 0 | 0 | 0 | 48 | 15 | 118 | 233 | 380 | 450 | 519 | 529 | 2292 |
| Subtotal RDTEN | 490 | 895 | 1002 | 1120 | 1089 | 803 | 621 | 659 | 880 | 1005 | 839 | 703 | 10106 |
| **Shipbuilding and Conversion, Navy (SCN) account** | | | | | | | | | | | | | |
| DDG-1000 | 0 | 0 | 0 | 220 | 285 | 1285 | 1401 | 0 | 0 | 0 | 0 | 0 | 3191 |
| *Construction* | *0* | *0* | *0* | *0* | *8* | *825* | *1401* | *0* | *0* | *0* | *0* | *0* | *2234* |
| *DD/NRE*[d] | *0* | *0* | *0* | *220* | *277* | *460* | *0* | *0* | *0* | *0* | *0* | *0* | *957* |
| DDG-1001 | 0 | 0 | 0 | 84 | 421 | 1272 | 1401 | 0 | 0 | 0 | 0 | 0 | 3179 |
| *Construction* | *0* | *0* | *0* | *0* | *8*[c] | *839* | *1401* | *0* | *0* | *0* | *0* | *0* | *2248* |
| *DD/NRE*[d] | *0* | *0* | *0* | *84* | *413* | *433* | *0* | *0* | *0* | *0* | *0* | *0* | *930* |
| DDG-1002 | 0 | 0 | 0 | 0 | 0 | 0 | 151 | 2412 | 0 | 0 | 0 | 0 | 2563 |
| *Construction* | *0* | *0* | *0* | *0* | *0* | *0* | *151*[e] | *2338* | *0* | *0* | *0* | *0* | *2489* |
| *Plans* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *74* | *0* | *0* | *0* | *0* | *74* |
| DDG-1003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 2450 | 0 | 0 | 0 | 2501 |
| DDG-1004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 2215 | 0 | 0 | 2266 |
| DDG-1005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 2320 | 0 | 2370 |
| DDG-1006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 2065 | 2115 |
| CG(X) 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3235 | 0 | 0 | 3235 |
| CG(X) 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3064 | 3064 |
| Subtotal SCN | 0 | 0 | 0 | 0 | 706 | 2557 | 2954 | 2463 | 2501 | 5500 | 2370 | 5129 | 24484 |
| **TOTAL** | **490** | **0** | **1002** | **304** | **1795** | **3360** | **3575** | **3122** | **3381** | **6505** | **3209** | **5832** | **34590** |

**Source:** Navy office of Legislative Affairs, March 28, 2007.

a. Figures do not include $1,111.4 million in RDT&E funding provided for DD-21/DD(X) program in FY1995-FY2001. Figures also do not include funding for Congressional adds in PE 0604300N. Additional funding required after FY2013.

b. Does not include RDTEN funding for CG(X) radar in PE 0604501N. FY2006 funding includes $30 million Congressional add.

c. Funding for procurement of long lead time materials (forgings) for AGS.

d. Detail design and non-recurring engineering costs for the class, including NRE costs for mission systems.

e. Funding for procurement of long lead time materials for AGS, external communications, and land-based testing.

f. CG(X) Analysis of Alternatives (AOA) is in progress; AOA report expected late in FY2007.

On May 25, 2005, the Navy announced that, in light of Section 1019 of P.L. 109-13, it wanted to shift to the current "dual-lead-ship" acquisition strategy, under which two DDG-1000s were procured in FY2007, with one to be designed and built by NGSS and the other by GD/BIW. (As mentioned earlier, each ship is being split-funded (i.e., incrementally funded) in FY2007 and FY2008.)

Section 125 of the FY2006 defense authorization act (H.R. 1815/P.L. 109-163) again prohibited the Navy from using a winner-take-all acquisition strategy for procuring its next-generation destroyer. The provision effectively requires the participation of at least one additional shipyard in the program but does not specify the share of the program that is to go to the additional shipyard.

A Defense Acquisition Board (DAB) meeting scheduled for April 29, 2005, to grant the DDG-1000 "Milestone B" approval to proceed was postponed, reportedly because of disagreement between the Navy and CAIG over estimated DDG-1000 procurement costs. The meeting was convened on November 10, 2005, but the DAB did not reach a decision at the meeting. The DAB instead requested more information about the program.

On November 23, 2005, Kenneth Krieg, the USD AT&L, granted Milestone B approval for the DDG-1000, permitting the program to enter the System Development and Demonstration (SDD) phase. Krieg also approved a low rate initial production quantity of eight ships. (The Navy now wants to build seven.) Krieg approved the Navy's proposed dual-lead-ship acquisition strategy. The November 23, 2005, memorandum from Krieg about his decision states:

> On November 10, 2005, I chaired a Defense Acquisition Board (DAB) review of the Navy's request for Milestone B approval for the DD(X) program. Based on that meeting and subsequent discussions held on November 22, 2005, I approve Milestone B for DD(X) and authorize the program's entry into the System Development and Demonstration phase of the acquisition process....
>
> I have also separately approved the DD(X) Acquisition Program Baseline and Acquisition Strategy Report (ASR). While there are differences between the OSD Cost Analysis Improvement Group's cost estimate and the Navy's cost estimate, I understand the differences and direct the Navy to fund the program to its cost estimate. I direct the Navy to submit, for my approval, an implementation plan for management controls to monitor the major cost estimate differences by January 31, 2006.
>
> The Navy will return for a DAB Program Review before the Navy exercises the contract options for construction of the two lead ships. The Navy will provide an updated ASR and an updated cost assessment prior to this review.

The Navy in 2006 said it planned to review the acquisition strategy for the third and following ships in the program in late-2006. The Navy has not ruled out the possibility of using competition to determine who will build these ships.

## CG(X) Cruiser

The CG(X) is the Navy's planned replacement for the CG-47s. The Navy wants to procure the first CG(X) in FY2011 and the second in FY2013.[15] The Navy's planned 313-ship fleet calls for a total of 19 CG(X)s. The Navy's FY2008 30-year shipbuilding plan calls for procuring the third CG(X) in FY2014, two per year from FY2015 through FY2021, and the final two CG(X)s in FY2022 and FY2023 (see **Table 3**). **Table 2** shows CG(X) (and DDG-1000) funding through FY2013.

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[15] A 30-year shipbuilding plan that the Navy submitted to Congress in May 2003 called for the first CG(X) to be procured in FY2018. The FY2006-FY2011 FYDP submitted to Congress in February 2005 accelerated the planned procurement of the lead CG(X) to FY2011.

The CG-47s are multimission ships with an emphasis on air defense. The Navy wants the CG(X) to be a multimission ship with an emphasis on air defense and ballistic missile defense (BMD).[16] The Navy plans to equip the CG(X) with a powerful new radar capable of supporting BMD operations, perhaps more missile-launch tubes than are on the DDG-1000, and perhaps one 155mm Advanced Gun System (AGS), or none, as opposed to two AGSs on the DDG-1000.

The Navy is currently assessing CG(X) design options in a study called the CG(X) Analysis of Alternatives (AOA), known more formally as the Maritime Air and Missile Defense of Joint Forces (MAMDJF) AOA. The Navy initiated this AOA in the second quarter of FY2006 and plans to complete it by mid-September 2007. Navy plans call for Milestone A review of the CG(X) program in the first quarter of FY2008, preliminary design review (PDR) in the third quarter of FY2010, critical design review (CDR) in the third quarter of FY2011, and Milestone B review in the fourth quarter of FY2011.

Although the CG(X) AOA may be examining a wide range of design options for the CG(X), the Navy has publicly stated that it prefers a CG(X) design based on the design of its new 14,500-ton DDG-1000 destroyer. The potential for using the DDG-1000 design for the CG(X) was one of the Navy's arguments for moving ahead with the DDG-1000 program. At an April 5, 2006, hearing, a Navy admiral in charge of shipbuilding programs, when asked what percentage of the CG(X) design would be common to that of the DDG-1000 (previously called the DD(X)), stated the following:

> [W]e haven't defined CG(X) in a way to give you a crisp answer to that question, because there are variations in weapons systems and sensors to go with that. But we're operating under the belief that the hull will fundamentally be — the hull mechanical and electrical piece of CG(X) will be the same, identical as DD(X). So the infrastructure that supports radar and communications gear into the integrated deckhouse would be the same fundamental structure and layout. I believe to accommodate the kinds of technologies CG(X) is thinking about arraying, you'd probably get 60 to 70 percent of the DD(X) hull and integrated (inaudible) common between DD(X) and CG(X), with the variation being in that last 35 percent for weapons and that sort of [thing]....
>
> The big difference [between CG(X) and DDG-1000] will likely [be] the size of the arrays for the radars; the numbers of communication apertures in the integrated deckhouse; a little bit of variation in the CIC [Combat Information Center — in other words, the] command and control center; [and] likely some variation in how many launchers of missiles you have versus the guns.[17]

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[16] For more on the Navy's role in ballistic missile defense, see CRS Report RL33745, *Sea-Based Ballistic Missile Defense — Background and Issues for Congress*, by Ronald O'Rourke.

[17] Source: Transcript of spoken testimony of Rear Admiral Charles Hamilton II, Program Executive Officer For Ships, Naval Sea Systems Command, before the Projection Forces Subcommittee of House Armed Services Committee, April 5, 2006. The inaudible comment may have been a reference to the DDG-1000's integrated electric-drive propulsion system. Between the two paragraphs quoted above, the questioner (Representative Gene Taylor) (continued...)

Depending on its exact features, a CG(X) based on the DDG-1000 hull design might have a procurement cost roughly equal to that of the DDG-1000, or perhaps somewhat higher. The procurement cost shown in the FY2007-FY2011 FYDP for the lead CG(X) (see **Table 2**) appears consistent with a design that is roughly equal in cost to, or perhaps somewhat more expensive than, the DDG-1000.

For additional discussion of CG(X) design options, see CRS Report RS22559, *Navy CG(X) Cruiser Design Options: Background and Oversight Issues For Congress*, by Ronald O'Rourke.

**Table 3** shows projected procurement of DDG-1000s, CG(X)s, and DDG(X)s as shown in the Navy's FY2008 30-year shipbuilding plan. The DDG(X), not to be confused with DD(X) (the former name of the DDG-1000), is the Navy's long-term notional projected replacement for today's DDG-51 Aegis destroyers.

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[17] (...continued)
asked: "So the big difference [between CG(X) and DDG-1000] will be what?"

## Table 3. Projected Procurement of Cruisers and Destroyers

| FY | DDG-1000 | CG(X) | DDG(X)[b] |
|---|---|---|---|
| 07 | 2[a] | | |
| 08 | 0[a] | | |
| 09 | 1 | | |
| 10 | 1 | | |
| 11 | 1 | 1 | |
| 12 | 1 | | |
| 13 | 1 | 1 | |
| 14 | | 1 | |
| 15 | | 2 | |
| 16 | | 2 | |
| 17 | | 2 | |
| 18 | | 2 | |
| 19 | | 2 | |
| 20 | | 2 | |
| 21 | | 2 | |
| 22 | | 1 | 1 |
| 23 | | 1 | |
| 24 | | | 2 |
| 25 | | | 3 |
| 26 | | | 3 |
| 27 | | | 3 |
| 28 | | | 3 |
| 29 | | | 3 |
| 30 | | | 3 |
| 31 | | | 3 |
| 32 | | | 3 |
| 33 | | | 3 |
| 34 | | | 3 |
| 35 | | | 3 |
| 36 | | | 3 |
| 37 | | | 3 |

**Source:** U.S. Department of the Navy, *Draft Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2008*.

a. Each of the two DDG-1000s procured in FY2007 is being split-funded (i.e., incrementally funded) across FY2007 and FY2008.
b. The DDG(X), not to be confused with DD(X) (the former name of the DDG-1000), is the Navy's projected long-term notional replacement for the Navy's existing DDG-51s.

# Oversight Issues for Congress

## Accuracy of Navy Cost Estimates

Although the Navy substantially increased estimated DDG-1000 procurement costs between 2004 and 2005, some observers believe the Navy's estimates are still too low. The Cost Analysis Improvement Group (CAIG) within the Office of the Secretary of Defense (OSD) reportedly believed in 2005 that DDG-1000 procurement costs may be 20% to 33% higher than the Navy's estimates.[18] A Congressional Budget Office (CBO) official stated in 2005 that the CAIG's estimate for the lead ship might be $4.1 billion, while its estimate for the fifth ship might be $3.0 billion.[19] CBO itself estimated in 2005 that the lead ship may cost as much as $4.7 billion, and that the fifth ship may cost $3.4 billion.[20] **Table 4** summarizes these estimates.

**Table 4. Estimated DDG-1000 Unit Procurement Costs**
(billions of dollars)

| | Navy estimate | Reported CAIG estimate in 2005 | CBO estimate in 2005 |
|---|---|---|---|
| **Lead ship** | $3.2 | $4.1 | $4.7 |
| **Fifth ship** | $2.3 | $3.0 | $3.4 |

**Source:** U.S. Navy data and July 20, 2005 CBO testimony before Projection Forces Subcommittee of House Armed Services Committee. The CAIG figures shown are from the CBO testimony, which CBO stated are according to an unconfirmed report about the CAIG estimates.

CBO has also questioned the accuracy of the Navy's estimate of the annual operating and support (O&S) cost of a DDG-1000 compared to that of a DDG-51. The Navy estimates that over a 35-year life cycle, a DDG-1000 would cost an average of about $12 million or $13 million less per year to operate and support than a DDG-51. CBO estimated in 2005 that the reduction in O&S costs for a DDG-1000 relative to a DDG-51 might range from zero to $10 million per year.[21]

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[18] Tony Capaccio, "Destroyer May Cost 33% More Than Navy Budgeted, Pentagon Says," *Bloomberg.net*, May 4, 2005; Christopher P. Cavas, "Rising Costs of DD(X) Threaten U.S. Fleet Plans," *DefenseNews.com*, May 2, 2005; Christopher J. Castelli, "Pentagon Postpones DD(X) DAB Meeting To Resolve Cost Estimates," *Inside the Navy*, May 2, 2005.

[19] Spoken testimony (transcript of hearing) of J. Michael Gilmore, Assistant Director for National Security, Congressional Budget Office, at a July 20, 2005, hearing on the DDG-1000 program before the Projection Forces Subcommittee of the Hose Armed Services Committee. Gilmore said these figures are from an unconfirmed report about the CAIG estimates.

[20] Ibid.

[21] Statement of J. Michael Gilmore, Assistant Director for National Security, Congressional Budget Office, [on] *The Navy's DD(X) Destroyer Program*, in U.S. Congress, House Committee on Armed Services, Subcommittee on Projection Forces, July 19, 2005, p. 5.

## Program Affordability and Cost Effectiveness

**Procurement Cost Affordability.** At the end of a July 19, 2005, hearing on the DDG-1000 program before the Projection Forces Subcommittee of the House Armed Services Committee, DOD and Navy witnesses were asked to provide the subcommittee with their own individual views on the procurement cost figures at which the lead DDG-1000 and a follow-on DDG-1000 (defined as the fifth ship) would become unaffordable. At the beginning of part two of the hearing, which was held on July 20, the chairman of the subcommittee, Representative Roscoe Bartlett, stated that the figures provided by the witnesses ranged from $4 billion to $4.5 billion for the lead ship and $2.5 billion to $2.9 billion for the fifth ship. As shown in **Table 5**, the 2005 CAIG and CBO estimates discussed earlier are at or above these figures.

**Table 5. Views on Maximum Affordable DDG-1000 Cost**
(billions of dollars)

| | Navy estimate | DOD/Navy 2005 views on maximum affordable cost | Reported CAIG estimate in 2005 | CBO estimate in 2005 |
|---|---|---|---|---|
| **Lead ship** | $3.2 | $4.0-$4.5 | $4.1 | $4.7 |
| **Fifth ship** | $2.3 | $2.5-$2.9 | $3.0 | $3.4 |

**Source:** U.S. Navy data and transcript of July 20, 2005, hearing before Projection Forces Subcommittee of House Armed Services Committee. See also the source note for the previous table.

The Navy argues that the DDG-1000 is affordable in terms of procurement cost because it is confident in its DDG-1000 procurement cost estimates, which are much less than the maximum-affordable procurement cost figures in **Table 5**. Skeptics could argue that the DDG-1000 is not affordable in terms of procurement cost because the 2005 CAIG and CBO procurement cost estimates for the ship are at or above the maximum-affordable figures in **Table 5**. They could also argue that the Navy's decision to reduce the planned DDG-1000 procurement from an originally envisaged total of 16 to 24 ships to the currently planned total of 7 ships, and the projected long-term shortfall in cruisers and destroyers (see discussion below), are evidence that, in terms of procurement cost, the DDG-1000 is not affordable in the numbers the Navy needs.

**Total Life-Cycle Cost Affordability.** The Navy argues that, in terms of total life-cycle cost (i.e., procurement plus lifetime O&S cost), the DDG-1000 is more affordable than might appear from looking only at procurement cost, because the ship will have lower lifetime O&S costs than existing Navy cruisers and destroyers. As mentioned above, the Navy estimates that over a 35-year life cycle, a DDG-1000 would cost an average of about $12 million or $13 million less per year to operate and support than a DDG-51. Over a 35-year life, this equates to a savings of $420 million to $455 million in O&S costs relative to a DDG-51. On this basis, the Navy argues that a force of 10 DDG-51s would have a total 35-year O&S cost $4.2 billion to $4.5 billion less than that of force of 10 DDG-51s.

Skeptics could argue that reducing a ship's future O&S costs, though desirable, does not make that ship any more affordable to procure in the budget that funds its procurement. Skeptics could also argue that, in terms of total life-cycle cost, the DDG-1000 is not as affordable as the Navy argues, for the following reasons:

- The Navy's estimated 35-year O&S savings of $420 million to $450 million only partially offsets difference between the DDG-1000's higher procurement cost and the procurement cost of a DDG-51 when DDG-51s are procured at a rate of two per year.

- Office of Management and Budget (OMB) Circular A-94[22] and standard business procedures call for future funding flows to be calculated on a present-value basis so as to capture the investment value of money over time. When calculated on this basis, the single-ship 35-year savings figure is reduced by about 46%, to $226 million to $242 million, and the 10-ship 35-year savings figure of $4.5 billion (assuming procurement of one ship per year) is reduced by about 53%, to about $2.1 billion.[23]

- The above calculations accept the Navy's estimate that a DDG-1000 would, on a 35-year basis, have an annual O&S cost $12 million to $13 million less than that of a DDG-51. As mentioned above, CBO has questioned the accuracy of the Navy's estimate of relative DDG-1000 and DDG-51 O&S costs, and has estimated that the difference might range from zero to $10 million per year.

**Table 6** compares follow-ship DDG-51 and DDG-1000 total procurement and life-cycle O&S costs using figures from the discussion above. The table uses constant FY2007 dollars, which results in some adjustments to the above figures. As can be seen in the table, on a present-value basis, the combined procurement and 35-year life-cycle O&S cost of the follow-on DDG-1000 is 16% greater than that of the DDG-51 using the Navy's estimates, or 91% to 101% greater using CBO's estimates.

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[22] U.S. Office of Management and Budget, *Circular A-94, Guidelines And Discount Rates For Benefit-Cost Analysis of Federal Programs*, available at [http://www.whitehouse.gov/omb/circulars/a094/a094.pdf].

[23] CRS calculations using the 3.1% real discount rate set forth in **Appendix C** (Revised January 2005) for discounting constant-dollar flows of 30 years or more.

**Table 6. Follow-ship DDG-51 and DDG-1000 Costs**
(millions of constant FY2007 dollars)

| | Constant FY2007 dollars | | | Present-value calculation | | |
|---|---|---|---|---|---|---|
| | Procure-ment cost | 35-year lifecycle O&S cost | Total | Procure-ment cost | 35-year lifecycle O&S cost | Total |
| **Navy Estimate** | | | | | | |
| Follow-on DDG-51 | 1,393 | 2,115 | 3,508 | 1,393 | 1,133 | 2,526 |
| Follow-on DDG-1000 | 2,058 | 1,627 | 3,685 | 2,058 | 871 | 2,929 |
| DDG-1000 less DDG | 665 | (488) | 177 | 665 | (262) | 403 |
| DDG-1000 as % DDG-51 | 148% | 77% | 105% | 148% | 77% | 116% |
| **CBO Estimate (with $10-million annual DDG-1000 O&S cost savings vs. DDG-51)** | | | | | | |
| Follow-on DDG-51 | 1,393 | 1,120 | 2,513 | 1,393 | 600 | 1,993 |
| Follow-on DDG-1000 | 3,400 | 770 | 4,170 | 3,400 | 412 | 3,812 |
| DDG-1000 less DDG | 2,007 | (350) | 1,657 | 2,007 | (188) | 1,819 |
| DDG-1000 as % DDG-51 | 244% | 69% | 166% | 244% | 69% | 191% |
| **CBO Estimate (with zero annual DDG-1000 O&S cost savings vs. DDG-51)** | | | | | | |
| Follow-on DDG-51 | 1,393 | 1,120 | 2,513 | 1,393 | 600 | 1,993 |
| Follow-on DDG-1000 | 3,400 | 1,120 | 4,520 | 3,400 | 600 | 4,000 |
| DDG-1000 less DDG | 2,007 | 0 | 2,007 | 2,007 | 0 | 2,007 |
| DDG-1000 as % DDG-51 | 244% | 100% | 180% | 244% | 100% | 201% |

**Source:** CRS calculations based on Navy and CBO DDG-1000 and DDG-51 cost data and a 3.1% real discount rate, as specified in Appendix C to OMB Circular A-94 for discounting constant-dollar flows of 30 years or more. DDG-51 procurement cost is an average unit cost based on a two-per-year procurement. (For a three-per-year procurement rate, the average unit procurement cost would be $1,251 million.)

**Cost Effectiveness.** The Navy argues that the DDG-1000 would be cost effective because the higher procurement cost of the DDG-1000 compared to previous Navy surface combatants would be more than offset by the DDG-1000's numerous and significant improved capabilities.[24] Skeptics could argue that these

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[24] The Navy states that, compared to the DDG-51, these capability improvements include, among other things:

— three-fold improvement in capability against anti-ship cruise missiles, including significantly better radar performance in situations involving near-land radar clutter;

— a 10-fold improvement in overall battle force defense capability, in part because of a 5-fold improvement in networking bandwidth capacity;

— 15% more capability to defend against group attacks by enemy surface craft (i.e., "swarm boats");

— a 50-fold improvement (i.e., reduction) in radar cross-section, which dramatically enhances survivability and reduces by half the total number of missiles that need to be fired in an intercept engagement;

— a 10-fold increase in operating area against mines in shallow-water regions;

(continued...)

capability improvements, though significant, are not worth the ship's cost, particularly if that cost is closer to the CAIG or CBO estimates than to the Navy's estimates, and that if the DDG-1000's most-needed contribution to fleet capabilities is the naval surface fire support capability provided by the ship's two AGSs, then the DDG-1000 represents a very expensive way to add this capability to the fleet.

## Mission Requirements

The DDG-1000's size and procurement cost do not appear to have been driven by any one technology or payload element, but rather by the ship's total collection of payload elements, which reflect requirements to perform various missions. These payload elements include, among other things:

- more gunfire capability than any cruiser the Navy has built since World War II;
- a vertical launch system (VLS) whose weapon storage volume and weapon weight capacity are between that of the DDG-51 and Aegis cruiser designs;[25]

[24] (...continued)

— 3 times as much naval surface fire support capability, including an ability to answer 90% of Marine Corps calls for fire within 5 minutes, permitting the ship to meet stated Marine Corps firepower requirements — a capability otherwise unavailable in the surface fleet — giving the ship a capability roughly equivalent to one-half of an artillery battalion, and permitting a 65% reduction in Marine Corps artillery;

— a ship design that allows underway replenishment of gun shells, creating the equivalent of an almost-infinite ammunition magazine and permitting nearly continuous fire support;

— about 10 times as much electrical capacity available for ship equipment, giving the ship an ability to support future electromagnetic rail guns and high-energy laser weapons; and

— features such as an automated fire-suppression system, peripheral vertical launch system, and integrated fight-through-damage power system that significantly increase ship survivability.

(Source: Points taken from Statement of Admiral Vern Clark, U.S. Navy, Chief of Naval Operations, Before The House Armed Services Committee Projection Forces Subcommittee, July 19th, 2005, and Statement of The Honorable John J. Young, Jr., Assistant Secretary of the Navy (Research, Development and Acquisition), and RADM Charles S. Hamilton, II, Program Executive Officer For Ships, Before the Projection Forces Subcommittee of the House Armed Services Committee on DD(X) Shipbuilding Program, July 19, 2005.)

[25] Although the DDG-1000 has 80 VLS cells, compared to 96 on the DDG-51 and 122 on the Aegis cruiser, the DDG-1000's VLS cells are larger. The Mk 41 VLS cells on DDG-51s and Aegis cruisers can fire a missile up to 21 inches in diameter, 21 feet in length, and about 3,000 pounds in weight. The Advanced VLS (AVLS) cells on the DDG-1000 can fire a missile up to 24 inches in diameter, 22 feet in length, and about 4,000 pounds in weight.

- an area-defense anti-air warfare (AAW) capability that in some respects is greater than that of the DDG-51;[26]
- sonars and other antisubmarine warfare (ASW) systems that are roughly equivalent to that of the DDG-51;[27]
- command facilities for a flag-level officer and his command staff — a feature that previously has been installed on cruisers but not destroyers;
- a large helicopter flight deck and a hangar and maintenance facilities for two helicopters or one helicopter and three UAVs;
- additional berthing, equipment-stowage space, and mission-planning space for a platoon of 20 special operations forces (SOF) personnel; and
- facilities for embarking and operating two 11-meter boats and four rubber raiding craft (as opposed to two 7-meter boats on the DDG-51).

The payload elements of the DDG-1000 design reflect an Operational Requirements Document (ORD) for the DDG-1000 that was approved by the Joint Staff of DOD in February 2004. Key performance parameters included in this document include having two AGSs that can each fire 10 rounds per minute, for a total of 20 rounds per minute.[28] DOD states that

> During the restructuring of the DD-21 program into the DD(X) program, the Navy re-evaluated each DD-21 Key Performance Parameter (KPP) to determine the potential for minimizing the size of the ship and ultimately the cost. The Navy made many adjustments and the resulting DD(X) KPPs represent the Navy's minimum requirements. No other known alternative meets all of the

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[26] The Navy states that radars on the DDG-1000 and DDG-51 are roughly equivalent in terms of dB gain (sensitivity) and target resolution, that the firm track range of the DDG-1000's dual-band radar — the range at which it can maintain firm tracks on targets — is 25% greater for most target types than the firm track range of the DDG-51's SPY-1 radar, that the DDG-1000's radar has much more capability for resisting enemy electronic countermeasures and for detecting targets amidst littoral clutter, that the DDG-1000's AAW combat system would be able to maintain 10 times as many tracks as the DDG-51's Aegis system, and that the two ships can support roughly equal numbers of simultaneous AAW engagements. Given the features of the DDG-1000's AAW system, plus its much-greater C4I/networking bandwidth, the Navy has stated that replacing a DDG-51 with a DDG-1000 in a carrier strike group would increase the strike group's AAW capability by about 20%.

[27] The Navy states that due to differences in their sonar designs, the DDG-1000 would have more littoral-water ASW capability, while the DDG-51 would have more blue-water ASW capability.

[28] Statement by The Honorable Kenneth J. Krieg, Under Secretary of Defense (Acquisition, Technology and Logistics), Before the Subcommittee on Projection Forces, House Armed Services Committee, United States House of Representatives, July, 19, 2005, p. 2.

> DD(X) KPPs and provide the sustained, precision, long-range naval surface fire support that the United States Marine Corps requires.[29]

Skeptics could argue that, notwithstanding the February 2004 DDG-1000 ORD, at least some requirements for the DDG-1000 are not clear. A November 2006 GAO reported states:

> In December 2005, more than a decade after the Navy and Marine Corps began to formulate requirements, agreement was reached on the capabilities needed for naval surface fire support. However, quantifiable measures are still lacking for volume of fire — the delivery of a large quantity of munitions simultaneously or over a period of time to suppress or destroy a target. Until further quantifiable requirements are set for volume of fire, it is difficult to assess whether additional investment is necessary or the form it should take.[30]

Skeptics could argue that with estimated DDG-1000 procurement costs now much higher than they were in February 2004, and in light of the effect that increased cost appears to have had in reducing planned DDG-1000 procurement, the February 2004 ORD might not reflect a sufficiently up-to-date consideration of how increasing DDG-1000 capability (and therefore cost) might reduce DDG-1000 numbers and therefore reduce the collective capability of the total DDG-1000 force. In light of the reduction in planned DDG-1000 procurement, skeptics could argue, certain capabilities that might have been viewed as desirable in February 2004 might now be viewed as less desirable because of their role in increasing DDG-1000 unit cost and thereby reducing planned DDG-1000 procurement.

Some observers speculate that the Navy and DOD established requirements for the DDG-1000 without a full appreciation of how large and expensive a ship design the requirements would generate. Naval analyst Norman Friedman, the author of numerous books on U.S. warship designs, states in a 2004 book on U.S. destroyer designs that

> In past [Navy ship design] practice, the naval policymakers in OpNav [the Office of the Chief of Naval Operations] would write a draft set of [ship] characteristics.... The Preliminary Design branch of BuShips [the Bureau of Ships] or NAVSEA [the Naval Sea Systems Command] would develop sketch designs to meet the requirements. Often the OpNav policymakers would find the results outrageous — for example, exorbitantly expensive. Such results would force them to decide just how important their various requests had been. Eventually Preliminary Design would produce something OpNav found acceptable, but that might not actually be built....
>
> In contrast to past practice, no preliminary design [for the DDG-1000] was drawn up to test the cost of various requirements. Each requirement was justified in operational terms, (e.g., a level of stealth that would reduce detectability by some percentage); but those sponsoring the ship had no way of knowing the impact that a particular combination of such requirements would have. Normally

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[29] Ibid, pp. 6-7.

[30] Government Accountability Office, *Defense Acquisitions[:] Challenges Remain in Developing Capabilities for Naval Surface Fire Support*, GAO-07-115, November 30, 2006.

> NAVSEA would have created a series of sketch designs for exactly that purpose.[31]

An August 2005 trade press article suggests that growth in DD-21/DDG-1000 requirements (and cost) over time may have been related to the disestablishment of a Navy ship-design board called the Ship Characteristics Improvement Board (SCIB) — an entity that the new Chief of Naval Operations, Admiral Michael Mullen, who became CNO on July 22, 2005, has reestablished under a new name:

> Adm. Michael Mullen, the chief of naval operations, has directed the Navy to re-establish a high-level panel to closely monitor and control the requirements and configurations of new ships in a bid to rein in the skyrocketing cost of new vessel procurement.
>
> Adm. Robert Willard, vice chief of naval operations, is leading the effort as part of a larger undertaking to draw up alternative options for the Navy's current shipbuilding program....
>
> In essence, sources said, Mullen is looking to reconstitute the Ship Characteristics Improvement Board, which eventually became inactive in 2002. For more than 100 years, the Navy has maintained a high-level group of officials to advise service leaders on ship design and configuration. This group, established in 1900 as the General Board has gone through many name changes, including the Ship Characteristics and Improvement Board in the early 1980s and, until 2002, the Ship Characteristics and Improvement Panel.
>
> Navy officials say that the panel's oversight began to wane in the late 1990s, just as the DD-21 program — originally envisioned as a $750 million replacement for Spruance-class destroyers — took off, before becoming officially inactive in 2002. Requirements during this time were added to the new destroyer program, some of which raised eyebrows in the Navy, such as the need for a flag officer quarters. No other ship in that class has accommodations for an admiral. Still, the DDG-1000 has come to be regarded as a technology carrier for future surface ships and the price tag has ballooned to $3 billion a copy.
>
> Mullen's goal, spelled out in a July 25 memo to Willard and provided to *InsideDefense.com*, is to put in place a "process that adequately defines warship requirements and manages changes to those requirements (e.g. Ship Characteristics Improvement Board) in a disciplined manner, with cost and configuration control as the paramount considerations."...
>
> A recent RAND study conducted at the request of Mullen's predecessor, retired Adm. Vern Clark, concluded that a key cause for climbing ship costs is the number of requirements tacked on to a program, according to a consultant familiar with the findings of the study, which has not been made public.
>
> "So, what I think Mullen has in the back of his head is, 'I've got to get the requirements process for ships back under control or we're always going to end

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[31] Norman Friedman, *U.S. Destroyers, An Illustrated Design History, Revised Edition*. Annapolis, Naval Institute Press, 2004, pp. 437 and 447-448. Punctuation as in the original.

> up, every time we talk about a new destroyer, with a $3 billion ship,'" said a former senior Navy official.
>
> This senior official, who was in a key Pentagon position as the DD-21 program commenced, said that without a panel overseeing the ship's configuration and true requirements the new destroyer program became weighed down with capabilities that carried a high price tag.
>
> "In hindsight, we realized that we had put requirements on the ship that no one had really vetted for its cost impact on the ship. For example, it was to operate acoustically silent and risk free in minefields," said the official. "If the SCIB had existed, this probably would not have happened."[32]

A March 2007 report from the Center for Strategic and Budgetary Assessments (CSBA) makes a similar point:

> For nearly a century, the Navy's SCIB — a group of high-ranking DoN {department of the Navy] officials — worked to balance desired warship warfighting requirements against their impact on a ship's final design and production costs. The primary reason why the Navy lost cost control over the DD-21/DD(X)/DDG-1000 was that just as the ship entered its design definition phase, the power of the Navy's SCIB was waning, replaced by a Joint requirements definition process with no fiscal checks and balances.[33]

Some observers, such as Norman Friedman, have raised questions about the Navy's decision to use a tumblehome (i.e., inward-sloping) hull for the DDG-1000. A 2006 magazine article by Friedman, for example,

- raises questions about the implications of a tumblehome hull for the ship's ability to deal with underwater damage;[34]
- asks whether the Navy knew at the outset of the DDG-1000 design process how much a decision to incorporate a tumblehome hull (and other survivability features) would increase the size of the ship; and
- questions whether the reduced visibility of the tumblehome hull to certain types of radars — the central reason for using a tumblehome hull — will be negated by its visibility to high-frequency (HF) surface wave radars that are now for sale on the international market.

The article, which refers to the DDG-1000 by the previous designation DD(X), states:

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[32] Jason Sherman, "Mullen To Bring Back Panel To Control Ship Configuration, Cost," *Inside the Navy*, August 8, 2005.

[33] Robert Work, *Know When To Hold 'Em, Know When To Fold 'Em: Thinking About Navy Plans For The Future Surface Battle Line*, Washington, Center For Strategic and Budgetary Assessments, 2007. p. 6. (CSBA Backgrounder, March 7, 2007).

[34] Other observers have also expressed concerns about the stability of the DDG-1000's tumblehome hull in certain see conditions. For a discussion, see Christopher P. Cavas, "Is New U.S. Destroyer Unstable?," *DefenseNews.com*, April 2, 2007.

In the case of the DD(X), the overriding requirement [in determining the hull design] was to minimise radar cross section — stealth. Much of the hull design was dictated by the attempt to reflect radar pulses away from the radar emitting them, so that radar returns would be minimised. By now the main technique is well known: slope all flat surfaces and eliminate the corner reflector created by the juncture of the hull and water....

If the ship could be stabilized sufficiently [against rolling from side to side], then she would never (or almost never) present any vertical surfaces [to a radar]. In the case of DD(X), stabilization is apparently achieved using ballast tanks. Such tanks in turn demand internal volume deep in the ship. Overall, stealth demands that as much as possible of the overall volume of the ship be buried in her hull, where the shape of the ship can minimise radar returns. That is why, paradoxically, a carefully-designed stealthy ship will be considerably larger — for more internal volume — than a less stealthy and more conventional equivalent. In the case of DD(X), there were also demands for improved survivability. The demand for stealth implied that anti-ship missiles were the most important envisaged threat. They hit above water, so an important survivability feature would be to put as much of the ship's vitals as possible below water — which meant greater demands for underwater volume....

Once the tumblehome hull had been chosen, [the ship's designers] were apparently also constrained to slope the bow back [creating a surface-piercing or ram bow] instead of, as is usual, forward....

There were numerous reasons why [past] naval architects abandoned tumblehome hulls and ram bows. Tumblehome reduces a ship's ability to deal with underwater damage. When a conventional flared (outward-sloping) hull sinks deeper in the water, its waterplane area [the cross-section of the ship where it intersects the plane of the water] increases. It becomes somewhat more stable, and it takes more water to sink it deeper into the water. Because the waterplane area of a tumblehome ship *decreases* as it draws more water, such a ship is easier to sink deeper. Tumblehome also apparently makes a ship less stable, and hence less capable of resisting extreme weather conditions. The larger the ship, the more extreme the weather has to be to make that critical. Critics of DD(X) have concentrated on the danger; defenders have concentrated on how extreme the critical weather condition would be.

In the end, whether the DD(X) hull form is attractive depends on an evaluation of anti-radar stealth as a design driver. About a decade ago, the DD(X) design concept was sold on the basis of a lengthy (and, incidentally, unclassified) analysis, the gist of which was that a heavily-armed surface combatant could play a decisive role in a Korean scenario...

The key analytic point... was that it would be very important for the ship to come reasonably close to enemy shores unobserved. That in turn meant anti-radar stealth. However, it soon came to mean a particular kind of anti-radar performance, against centimetric-wave radars [radars with wavelengths on the order of centimeters] of the sort used by patrol aircraft (the ship would fire [its weapons] from beyond the usual horizons of shore-based radars). As it happens, anti-ship missiles use much the same kinds of radars as patrolling aircraft, so it could be argued that the same anti-radar techniques would be effective in the end-game in which missiles would approach the ship....

Without access to files of the time, it is impossible to say whether those approving the [DDG-1000] project realised that its stealth and survivability characteristics would produce a 14,000 to 17,000 ton destroyer. About the same time that DD(X) characteristics (requirements) were being approved, the decision was taken at [the] Defense Department (not Navy) level that there would be no internal feasibility design. In the past, the feasibility stage had the very useful role of showing those setting requirements what their implications would be. At the very least, the Navy's senior leadership would have been given warning that they would have to justify a drastic jump in destroyer size when they wanted to build DD(X). That jump might well have been considered justified, but on the other hand the leadership might also have asked whether a somewhat less dramatic approach would have been acceptable.

About a decade after the requirements were chosen, with DD(X) well advanced, the situation with regard to stealth may be changing. Shaping is relevant only at relatively short [radar] wavelengths. For about a quarter-century, there has been talk of HF surface wave radars, which operate at wavelengths of about 10 to 200 meters — i.e. at wavelengths the size of a ship. Canada currently operates this type of radar, made by Raytheon, for surveillance of the Grand Banks; another is being tested in the Caribbean. Australia has bought this kind of radar to fill gaps in over-the-horizon radar coverage. Turkey is buying such radars for sale for some years. In 2005 it was reported unofficially that China had bought [a] Russian HF surface wave radar the previous year.

It seems almost certain that HF surface wave radar can defeat any kind of stealth shaping designed primarily to deal with shorter-wave[length] radars. Moreover, [HF surface wave] radars have an inherent maximum range (due to the way they operate) of about 180nm.... At long range [the radar's beam] is not nearly accurate enough to aim a missile. However, we can easily imagine a netted system which would use the long-range [HF surface wave] radar to define a small box within which the target ship would be. A missile with GPS [Global Positioning System] guidance could be flown to that box, ordered to search it....

If the argument given here is realistic, then the considerable sacrifices inherent in the DD(X) design no longer seem nearly as attractive. It can still be argued that a design like the DD(X) is attractive well out to sea, beyond the reach of coastal radars. In that case, however, there may be other signatures which can be exploited. For example, ships proceeding at any speed create massive wakes.... it is clear that the wake produces a radar return very visible from an airplane or, probably, from a space-based radar....

In the end, then, how much is stealth worth? As a way of avoiding detection altogether, probably less than imagined. That leaves the rather important end-game, the hope being that decoys of some sort greatly exceed actual ship radar cross-section. That is probably not a foolish hope, but it does not require the sort of treatment reflected in [the] DD(X).

Now, it may be that the Untied States typically faces countries which have not had the sense to buy anti-stealth radars (though we would hate to bet on that).

In that case, DD(X) may well be effectively invisible to them. So will a lot of less thoroughly stealthy ships.[35]

Potential oversight questions for Congress include the following:

- **SCIB and DDG-1000 requirements.** Are the DDG-1000's requirements partly a result of inadequate discipline, following the disestablishment of the SCIB, in the Navy's process for setting requirements for new ships? If the SCIB had remained in existence during the DD-21/DDG-1000 design process, which of the DDG-1000's current requirements would have been reduced or eliminated?

- **Tumblehome hull.** How much did the decision to use a tumblehome hull (and other survivability features) increase the size and cost of the DDG-1000? In the mid-1990s, when design work began on the ship now known as DDG-1000, how well did the Navy understand the relationship between using a tumblehome hull and ship size and cost? What effect does the tumblehome hull have on the DDG-1000's ability to deal with underwater damage? To what degree will HF surface wave radars negate the stealth characteristics of the DDG-1000 design?

- **AGSs.** Since the DDG-1000 is the only ship planned to carry AGSs, and since AGSs are viewed by the Marine Corps as necessary to meet Marine Corps requirements for naval surface fire support capability, should the AGSs be considered the most-critical payload element on the DDG-1000, and certain other payload elements, though desirable, as possibly less critical by comparison?

- **Hangar.** In light of the 167 current or planned helicopter hangar spaces on other Navy surface combatants (2 spaces on each of 22 Aegis cruisers and the final 34 DDG-51s, and at least 1 space on each of 55 LCSs), and the relatively limited number of Navy helicopters available for filling those spaces, how critical is it for the DDG-1000 to have a hangar with spaces for two helicopters? Would it be acceptable for the DDG-1000 instead to have only a helicopter landing platform and an ability to refuel and rearm helicopters, like the first 28 DDG-51s?

- **VLS tubes.** In light of the 8,468 vertical launch system (VLS) missile tubes on the Navy's planned force of 84 VLS-equipped Aegis ships (22 cruisers with 122 tubes each, 28 earlier DDG-51s with 90 tubes each, and 34 later DDG-51s with 96 tubes each), the ability of VLS tubes to store and fire either one 21-inch diameter

[35] Norman Friedman, "The New Shape of Ships," Naval Forces, No. II, 2006: 56-58, 60, 62-63. Italics as in the original. Friedman makes somewhat similar comments in chapter 17 (pages 431-450) of *U.S. Destroyers, An Illustrated Design History, Revised Edition*, op cit.

missile or four smaller-diameter Evolved Sea Sparrow Missiles (ESSMs), the ability in a networked force for a ship to control a missile fired by another ship, and the DDG-1000's key role in providing naval gunfire support with its two AGSs, how critical is it for the DDG-1000 to have 80 enlarged VLS tubes as opposed to a smaller number, such as 64, 48, or 32?

- **Command facilities.** In light of the flag-level command facilities on the 19 Aegis cruisers, as well as additional command facilities on aircraft carriers and planned amphibious assault ships, how critical is it for the DDG-1000 to have flag-level command facilities?

- **SOF support facilities.** In light of SOF support facilities on the Navy's planned force of four converted Trident submarines, or SSGNs (66 or more SOF personnel for each ship),[36] support facilities for smaller numbers of SOF on Navy attack submarines (SSNs), and the secondary SOF support role for the Navy's planned force of 55 LCSs, how critical is it for the DDG-1000 to have SOF support facilities?

- **AAW system.** In light of the Aegis area-defense AAW systems on the Navy's planned force of 84 Aegis ships — which, though not as capable in some respects as the DDG-1000's AAW system in littoral operating environments, would still be quite capable, particularly when numbers of Aegis ships are taken into account — how critical is it for the DDG-1000 to have an area-defense-capable AAW system, as opposed to a more modest point-defense AAW system capable of defending only the DDG-1000 itself (which might be closer to the more modest AAW system that was originally envisaged for the DD-21, the precursor to the DDG-1000)?[37]

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[36] For more on the SSGN program, see CRS Report RS21007, *Navy Trident Submarine Conversion (SSGN) Program: Background and Issues for Congress*, by Ronald O'Rourke.

[37] Earlier editions of this report also asked the following question:

> **Gun shell capacity.** In light of the DDG-1000 design feature that allows underway replenishment of gun shells, creating the equivalent of an almost-infinite ammunition magazine and permitting nearly continuous fire support, how critical is it for the DDG-1000 to have a total gun shell capacity of 920 shells, as opposed to a smaller number, such as 600?

A December 2005 press stated that, as part of an effort to reduce the cost of the DDG-1000, the Navy had reduced the magazine capacity of the design from 920 shells to 600. (Christopher P. Cavas, "U.S. Ship Plan To Cost 20% More," *Defense News*, December 5, 2005: 1, 8.)

## Contract Strategy and System Integration

As mentioned in the Background section, the Navy since September 30, 2005, has managed the DDG-1000 program through a series of separate contracts with major DDG-1000 program contractors, and consequently is acting in at least some respects as the overall system integrator for the program. This approach represents, to some degree, a turn away from the trend in recent years under which the services have transferred the overall system-integrator role to industry, and a return, to some degree, to an earlier acquisition approach under which the services acted as the overall system integrators. The Navy's decision to manage the DDG-1000 program this way follows actions begun in the 1990s, consistent with the strategy at the time of shifting the system-integrator role to industry, to reduce the number of people in the Navy's acquisition commands. Potential oversight questions for Congress include the following:

- Does the Navy retain sufficient in-house acquisition and technical expertise to perform the system-integration functions that the Navy is to perform under its DDG-1000 contracting strategy?

- Does the Navy's contracting strategy for the DDG-1000 program have any implications for how other defense acquisition programs should be pursued?

## Acquisition Strategy for Third and Subsequent Ships

As mentioned in the Background section, the Navy's intended acquisition strategy for the third and subsequent DDG-1000s is unclear. The Navy stated in 2006 that it intended to review the issue in late-2006. The issue has potentially significant implications for the industrial-base effects of the DDG-1000 program (see discussion below).

## Potential Program Implications for Industrial Base

The Navy's 30-year shipbuilding plan (see **Table 3**) calls for procuring an average of about 1.5 DDG-1000s/CG(X)s over the next 17 years. The light-ship displacement of the DDG-1000 (about 12,435 tons) is about 79% greater than that of the DDG-51 Flight IIA design (about 6,950 tons). If shipyard construction work for these two ship classes is roughly proportional to their light-ship displacements, and if the CG(X) is about the same size as the DDG-1000, then procuring an average of 1.5 DDG-1000s/CG(X)s per year might provide an amount of shipyard work equivalent to procuring about 2.7 DDG-51s per year. Splitting this work evenly between GD/BIW and the Ingalls shipyard that forms parts of NGSS might thus provide each yard with the work equivalent of about 1.35 DDG-51s per year.

Supporters of these two yards argued in the 1990s that a total of 3 DDG-51s per year (i.e., an average of 1.5 DDG-51s per year for each yard), in conjunction with other work being performed at the two yards (particularly Ingalls), was the minimum

rate needed to maintain the financial health of the two yards.[38] Navy officials in recent years have questioned whether this figure is still valid. Building the equivalent of about 2.7 DDG-51s per year equates to about 90% of this rate.

If GD/BIW were to build the second and fourth DDG-1000s, then the rather lengthy interval between GD/BIW's first ship (to be procured in FY2007) and its second ship (to be procured in FY2010) could reduce GD/BIW's ability to efficiently shift production from one ship to the next.

If affordability considerations limit DDG-1000/CG(X) procurement to one ship per year in FY2011 and subsequent years, the workload for the cruiser-destroyer industrial base in those years would be reduced substantially from levels that would be achieved under the Navy's 30-year plan. Procuring one DDG-1000/CG(X) per year might provide an amount of shipyard work equivalent to procuring about 1.8 DDG-51s per year, and splitting this work evenly between GD/BIW and Ingalls might provide each yard with the work equivalent of about 0.9 DDG-51s per year, which would be equivalent to 60% of the rate cited in the 1990s by supporters of the two shipyards as the minimum needed to maintain the financial health of the two yards.

If the Navy at some point holds a competition between the two yards for the right to build all remaining DDG-1000s, the yard that loses could experience a significant reduction in workloads, revenues, and employment levels.

# Options for Congress

## DDG-1000 Program

Potential options for Congress for the DDG-1000 program, some of which could be combined, and some of which overlap with options for the CG(X) program (see next section), include the following:

- approve the seven-ship DDG-1000 program as proposed by the Navy;
- use a block-buy contract for DDG-1000s procured during the five-year period FY2007-FY2011 or the five-year period FY2009-FY2013;
- as an annual affordability measure, limit DDG-1000/CG(X) procurement to a combined total of no more than one ship per year;

[38] See, for example, CRS Report 94-343, *Navy DDG-51 Destroyer Procurement Rate: Issues and Options for Congress*, by Ronald O'Rourke (out of print, available from author).

- as total-program affordability measure, limit DDG-1000/CG(X) procurement to a combined total of 12 ships (one for each of 12 planned carrier strike groups (CSGs));[39]

- procure no more than two DDG-1000s for use as technology demonstrators for future, less-expensive surface combatants, and supplement the industrial base with other work; and

- start design work now on a lower-cost naval gunfire support ship and/or a lower-cost cruiser-destroyer, and start procuring these ships, rather than additional DDG-1000s or CG(X)s, when these new designs are ready for procurement.

Supporters of the **second option** could argue that it could reduce the total cost of the DDG-1000s procured by a few percent. Opponents could argue that it would reduce DOD's flexibility for making adjustments in the shipbuilding plan, and similarly tie the hands of future Congresses — something that Congress traditionally tries to avoid in decisions on discretionary spending — by creating a commitment to procure a certain number DDG-1000s through FY2011 or FY2013.

The **third option** might be considered as a response to limits on Navy resources and desires for funding other Navy programs. This option would release DDG-1000/CG(X) procurement funding programmed for FY2011 and future years for application to other Navy programs. It would also increase DDG-1000/CG(X) unit procurement costs due to reduced economies of scale in production, and deepen the projected long-term cruiser-destroyer shortfall.

The **fourth option**, like the third option, might be considered as a response to limits on Navy resources and desires for funding other Navy programs. It could provide a limited number of DDG-1000s and CG(X)s for the fleet, while permitting procurement to shift to a follow-on design (such as the DDG(X), the Navy's planned replacement for the DDG-51s) sooner than under the Navy's current plan. This option would increase average DDG-1000/CG(X) unit acquisition costs due to the elimination from the program of ships that would have been further down the learning curve, as well as reduced amortization of up-front DDG-1000/CG(X) development and design costs.

The **fifth option**, might be consistent with a view that the DDG-1000 is not affordable or not cost effective. This option could release DDG-1000 procurement funding for application to other Navy programs. It could also have implications for the shipbuilding industrial base, particularly if the industrial base receives a smaller amount of other work in lieu of additional DDG-1000s.

The **sixth option** could reduce the average unit procurement cost of planned cruisers and destroyers, permitting a larger number of cruisers and destroyers to be procured for a given amount of funding. It would also likely reduce the average unit

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[39] Carrier strike group (CSG) is the Navy's term for what used to be called carrier battle group (CVBG).

capability of the future cruisers and destroyers. Below are discussions of two possibilities for lower-cost ships — a lower-cost naval gunfire support ship, and a lower-cost cruiser-destroyer.

**Lower-Cost Gunfire Support Ship.** CBO and Robert Work of the Center for Strategic and Budgetary Assessments (CSBA) have both suggested, as a lower-cost naval gunfire support ship, an AGS-equipped version of the basic hull design of the San Antonio (LPD-17) class amphibious landing ship. Such a ship might begin procurement in FY2009, following procurement of a final "regular" LPD-17 amphibious landing ship in FY2008. CBO estimates that an initial AGS-armed LPD-17 might cost about $1.9 billion, including $400 million detailed design and nonrecurring engineering costs, and that subsequent ships might cost about $1.5 billion each.[40]

**Lower-Cost Cruiser-Destroyer.** A new-design, lower-cost cruiser-destroyer might:

- start procurement as soon as FY2011, if design work were started right away;
- incorporate many of the same technologies now being developed for the DDG-1000 and CG(X);
- employ a modular, "plug-and-fight" approach to some of its weapon systems, like the LCS;
- be similar to the DDG-1000 and CG(X) in terms of using a reduced-size crew reduce annual operation and support costs;
- use a second-generation surface combatant integrated electric-drive propulsion system that is smaller and lighter than the first-generation system to be installed in the first DDG-1000s;[41]
- carry a payload — a combination of sensors, weapon launchers, weapons, and aircraft — that is smaller than that of the DDG-1000 or CG(X), but still sizeable; and
- be built in one or two variants — an air- and missile-defense version to replace the CG(X), which would preserve CG(X) radar capabilities while reducing other payload elements, and possibly also

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[40] See Congressional Budget Office, *Options for the Navy's Future Fleet*, May 2006, pp. 56-57 (Box 3-1).

[41] The integrated electric-drive system to be installed in the first DDG-1000s uses advanced induction motors. A second-generation system could use smaller and lighter motors and generators that employ permanent magnet or high-temperature superconducting technology. Both of these technologies are currently being developed. For more on these technologies, see CRS Report RL30622, *Electric-Drive Propulsion for U.S. Navy Ships: Background and Issues for Congress*, by Ronald O'Rourke. (July 31, 2000)

a surface fire support version to supplement the DDG-1000, which would preserve the DDG-1000's two AGSs while reducing other payload elements.

Notional options for a lower-cost cruiser-destroyer include, but are not limited to, the following:

- a ship displacing about 9,000 tons — about the same size as the DDG-51; or

- a ship displacing about 11,000 tons — about 25% less than the DDG-1000's displacement of about 14,500 tons, about the same size as the nuclear-powered cruisers procured for the Navy in the 1960s and 1970s, and about 1,800 tons larger than the DDG-51.

Such a ship might be based on either the DDG-51 hull design, which is a conventional flared hull that slopes outward as it rises up from the waterline, [42] or a new flared hull design, or a reduced-sized version of the DDG-1000's tumblehome (inwardly sloping) hull design.

The Navy in 2002 identified the following ship-design characteristics as items that, if varied, would lead to DDG-1000 concept designs of varying sizes, capabilities, and procurement costs:

- cruising range,
- maximum sustained speed,
- number of Advanced Gun Systems (AGSs) and AGS shells,
- hangar space for helicopters and UAVs,
- undersea warfare systems (i.e., sonars and mine countermeasures systems), and
- numbers and types of boats for special operations forces.

Using these variables, the Navy in 2002 developed notional DDG-1000 concept designs with estimated full load displacements ranging from 12,200 tons to about 16,900 tons. One of the concept designs, with an estimated full load displacement of about 12,700 tons, included 32 Advanced Vertical Launch System (AVLS) cells (rather than the DDG-1000's 80), two AGSs (like the DDG-1000), 600 AGS shells (like the DDG-1000), a maximum sustained speed a few knots lower than the DDG-1000's, and a helicopter flight deck smaller than the DDG-1000's. Another concept design, with an estimated full load displacement of about 12,200 tons, included 64 AVLS cells, 1 AGS, 450 AGS rounds, a maximum sustained speed a few knots lower than the DDG-1000's, and helicopter flight deck smaller than the DDG-1000's.

The Navy in 2003 developed another set of notional DDG-1000 concept designs with estimated full load displacements ranging from 11,400 tons to 17,500 tons. One

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[42] Using the DDG-51 hull in its current dimensions might produce a ship of about 9,000 tons; lengthening the DDG-51 hull with a mid-hull plug might produce a ship of about 11,000 tons.

of the concept designs, with an estimated full load displacement of 13,400 tons, included 64 AVLS cells, 1 AGS, and 450 AGS rounds. Another concept design, with an estimated full load displacement of 11,400 tons, included 32 AVLS cells, 1 AGS, and 300 AGS rounds.

The 2002 and 2003 notional DDG-1000 concept designs with displacements of less than 14,000 tons appear to have preserved other DDG-1000 features, such as the wave-piercing, tumblehome hull, the integrated electric drive system (though with reduced total power in at least some cases), the total ship computing environment, the autonomic fire-suppression system and other features permitting a reduced-sized crew, the DDG-1000 radar suite, the hull and towed-array sonars, medium-caliber guns for use against surface targets, and a helicopter hangar (though not necessarily as large a hangar as on the DDG-1000).

Reducing payload features a bit more than under the smallest of the 2002 and 2003 notional concept designs might lead to a design with a displacement of about 9,000 to 11,000 tons. The Navy has viewed designs of less than 14,000 tons as unsatisfactory because of their reduced individual capabilities. It is not clear, however, to what degree the Navy's assessment of such designs also takes into account the difference that size (and thus unit procurement cost) can have on the total number of ships that might be procured within available resources, and consequently on future cruiser-destroyer force levels. Total cruiser-destroyer force capability is dependent on both cruiser-destroyer unit capability and the total number of cruisers and destroyers.

For additional discussion of CG(X) design options, see CRS Report RS22559, *Navy CG(X) Cruiser Design Options: Background and Oversight Issues For Congress*, by Ronald O'Rourke.

**Notional Procurement Profiles With Lower-Cost Ships.** **Table 7** and **Table 8** show notional procurement profiles incorporating the ships described above. In **Table 7**, an AGS-equipped version of the basic LPD-17 hull design is procured to supplement the Navy's DDG-1000s, and an air- and missile-defense version of the smaller cruiser-destroyer is procured starting in FY2011 in lieu of the CG(X). In **Table 8**, a smaller cruiser-destroyer in two versions — an AGS-equipped version to supplement the Navy's DDG-1000s, and air- and missile-defense version in lieu of the CG(X) — is procured starting in FY2011.

**Table 7. Alternative With LPD (AGS) and Smaller Cruiser-Destroyer**
(annual quantities procured, FY2007-FY2021)

| | 07 | 08 | 09 | 10 | 11 | 12 | 13-21 | Total |
|---|---|---|---|---|---|---|---|---|
| DDG-1000 | 2[a] | 0[a] | 1 | 1 | | | | 4 |
| LPD (AGS)[b] | | | 1 | 1 | 1 | 2 | | 5 |
| SCD[c] | | | | | 1 | | 2/year | 19 |

**Source:** Prepared by CRS.
a. Each of the two ships to be procured in FY2007 is to be split-funded across FY2007 and FY2008.
b. Basic LPD-17 hull equipped with 2 Advanced Gun Systems (AGSs).
c. Air- and missile-defense version of smaller cruiser-destroyer (SCD), in lieu of CG(X).

**Table 8. Alternative With Smaller Cruiser-Destroyer**
(annual quantities procured, FY2007-FY2022)

| | 07 | 08 | 09 | 10 | 11 | 12 | 13-22 | Total |
|---|---|---|---|---|---|---|---|---|
| DDG-1000 | 2[a] | 0[a] | 1 | 1 | | 1 | | 5 |
| SCD[b] | | | | | 1 | | 2/year | 21[b] |

**Source:** Prepared by CRS.
a. Each of the two ships to be procured in FY2007 is to be split-funded across FY2007 and FY2008.
b. Includes 2 AGS-equipped versions of smaller cruiser-destroyer (SCD), for a total (along with 5 DDG-1000s) of 7 AGS-equipped ships, and 19 air- and missile-defense versions, in lieu of CG(X).

## CG(X) Program

Potential options for Congress for the CG(X) program, some of which could be combined, and some of which overlap with options for the DDG-1000 program (see the previous section), include the following:

- approve the CG(X) program as proposed by the Navy;
- use a block-buy contract or multiyear procurement for CG(X)s procured in future years;
- procure the CG(X) as a nuclear-powered ship (rather than as a conventionally powered ship, as planned by the Navy);
- defer procurement of the first CG(X) beyond FY2011 to permit additional procurement of DDG-1000s prior to commencement of CG(X) procurement;
- as an annual affordability measure, limit DDG-1000/CG(X) procurement to a combined total of no more than one ship per year;
- as total-program affordability measure, limit DDG-1000/CG(X) procurement to a combined total of nine ships (one for each of nine

planned expeditionary strike groups (ESGs)) or 11 ships (one for each of 11 planned carrier strike groups (CSGs));

- start design work now on a lower-cost cruiser based on a hull design smaller than the DDG-1000 hull, and start procuring this design, rather than a DDG-1000-based CG(X) design, when this smaller design is ready for procurement.

Points of discussion for some of these options are similar to points presented for analogous options in the previous section on options for the DDG-1000 program.

Regarding the **third option**, a nuclear-powered CG(X) would be more capable than a conventionally powered version because of the mobility advantages of nuclear propulsion, which include, for example, the ability to make long-distance transits at high speeds in response to distant contingencies without need for refueling. The Navy estimates that procuring the CG(X) as a nuclear-powered ship would likely increase its unit procurement cost by $600 million to $700 million dollars. If oil prices in coming years are high, much of the increase in unit procurement cost could be offset over the ship's service life by avoided fossil-fuel costs. Procuring the CG(X) as a nuclear-powered ship might result in at least part of the ship being built at one or both of the country's two nuclear-certified ship construction yards — Northrop Grumman Newport News (NGNN) of Newport, News, VA, and General Dynamics' Electric Boat Division (GD/EB) of Groton, CT, and Quonset, Point, RI.

For additional discussion of the option of procuring the CG(X) as a nuclear-powered ship, see CRS Report RL33946, *Navy Nuclear-Powered Surface Ships: Background, Issues, and Options for Congress*, by Ronald O'Rourke.

For further discussion of the **seventh option**, see CRS Report RS22559, *Navy CG(X) Cruiser Design Options: Background and Oversight Issues For Congress*, by Ronald O'Rourke.

## CSBA Report

A March 2007 report from the Center for Strategic and Budgetary Assessments (CSBA) on the Navy's surface combatant force makes a number of recommendations regarding existing and future surface combatants. **Appendix A** of this CRS report reprints these recommendations.

# FY2008 Legislative Activity

## FY2008 Defense Authorization Bill (H.R. 1585)

**House.** The House Armed Services Committee, in its report (H.Rept. 110-146) on the FY2008 defense authorization bill (H.R. 1585), recommended approval of the Navy's request for FY2008 procurement funding for the DDG-1000. The report recommended increasing the Navy's FY2008 request for research and development

funding for the DDG-1000 program by $9 million for work on permanent magnet motor technology. The report states:

> The budget request contained $503.4 million in PE [program element] 64300N for DDG 1000 total ships systems engineering, but contained no funds for continued development of the permanent magnet motor. The committee understands that the permanent magnet motor technology will save weight and increase fuel efficiency in the next generation of surface combatants, including the DDG 1000. The committee recommends an increase of $9.0 million in PE 64300N to complete design of the motor and motor control electronics. (Page 187)

**Senate.** The Senate Armed Services Committee, in its report (S.Rept. 110-77 of June 5, 2007) on the FY2008 defense authorization bill (S. 1547), recommended approval of the Navy's request for FY2008 procurement funding for the DDG-1000. The report recommended increasing the Navy's FY2008 request for research and development funding for the DDG-1000 program by $15 million, of which $9 million wold be for work on a permanent magnet motor system and $6 million would be for work on wireless encryption technology for use on Navy ships. The report states:

> *Permanent magnet motor*
>
> The budget request included $621.5 million in PE 64300N for [DDG-1000] destroyer total ship systems engineering. The budget request included no funding for completing the development and testing of the permanent magnet motor (PMM).
>
> Present Navy and Marine Corps electric propulsion and power generation systems are several times larger and heavier than mechanical drive equivalents, limited by very heavy generation equipment and propulsion motors. The PMM was developed to resolve this. Congress provided funding in fiscal year 2006 which the Navy and the contractor team used to complete factory testing, ship the PMM engineering development model to the Navy's land based test site, and begin testing.
>
> Because of the promise of this technology for future ship applications, the committee recommends an increase of $9.0 million to incorporate changes resulting from land based testing, repackage PMM design to reflect evolving DDG-1000 requirements, and perform shock analysis.
>
> *Wireless encryption technology*
>
> The budget request included $621.5 million in PE 64300N for [DDG-1000] destroyer total ship systems engineering, but included no funding to develop wireless encryption technology. With the reduced manning planned on the DDG-1000 and other vessels, the Navy will have to place greater reliance on automation and having the crews stay connected to the ships' computing environment. Absent better wireless encryption technology, the goal of being connected to all information systems will be problematic for very sensitive information. The committee recommends an increase of $6.0 million to develop better wireless encryption technology for use aboard Navy vessels. (Pages 203-204)

# Appendix A. CSBA Report on Navy Surface Combatants

A March 2007 report from the Center for Strategic and Budgetary Assessments (CSBA) discusses existing and future Navy surface combatants and makes the following recommendations (emphasis as in the original):

> **— First, "fold" the CG-21 hand: cancel all planned new CG-21s [i.e., DDG-1000s and CG(X)s] beyond the two DDG-1000s already authorized.**[43] A variation of this plan would be to build just one ship. By building two (or one) operational test beds/technology demonstrators, the Navy can recoup most of the previous "bets" made on the CG-21s. Having one or two test ships would allow further testing and refinement of the SPY-3 multifunction radar, which is to be installed on future aircraft carriers regardless of what happens with the DDG-1000, and perhaps on other ships. Over time, the ships could be modified to test other future surface combatant combat systems such as underwater combat systems or electronic warfare systems. Regardless of configuration, the ships would provide the battle fleet with a test article for new integrated power system components as well as electrically-powered weapons. In this role, the less capable advanced induction motor to be installed on the first two DDG-1000s ships will be as effective as the permanent magnet motor — the Navy's desired electric motor. The ships' larger VLS cells would allow the Navy to test larger diameter guided missiles. In fleet exercises, the ships would help to identify the true operational payoffs of ship stealth within the context of distributed naval battle networks. Finally, these large ships with small crews would help the Navy to refine the maintenance concepts for future optimally manned fleet combatants (i.e., warships with reduced crews).
>
> **— Second, "hold" the Aegis/VLS fleet: design a comprehensive, Aegis/VLS Battle Network Reliability and Maintenance (BNRAM) program, with the goal of producing the maximum number of interchangeable, Interim Large Battle Network Combatants. (I-LBNCs).** The Navy's ultimate goal is to shift to a new Large Battle Network Combatant, or LBNC — a far better description of future Total Force Battle Network [TFBN] ships-of-the-line than the multimission guided-missile "cruisers" and "destroyers" or general-purpose "destroyers" associated with today's legacy Total Ship Battle Force. Until they can be designed, betting an additional $10-15 billion on five or six additional DDG-1000s would appear to provide far less of a TFBN payoff than making a similar sized or even smaller bet on a well-thought-out and executed BNRAM program to convert the 84 programmed Aegis/VLS warships into more powerful I-LBNCs. This conversion program would be patterned after earlier modernization and conversion efforts, like the Fleet Reliability and Maintenance (FRAM) program, which converted many of the large legacy fleet of World War II destroyers into effective Cold War ASW escorts. The BNRAM would include a thorough mid-life upgrade to the ships' hull, machinery and electrical (HM&E) systems; a combat systems upgrade to allow the ships to counter emerging threats; and a battle network upgrade to allow the ships to operate as part of a coherent naval battle network. Consistent with battle network precepts, the intent of the BNRAM would be to bring as many ships as possible to a common

[43] The CSBA report uses the term CG-21s to refer collectively to DDG-1000s and CG(X)s.

I-LBNC combat system baseline. The BNRAM would also aim to lower substantially the operations and maintenance costs (O&M) costs necessary to operate the legacy Aegis/VLS fleet, in order to save money in the near term, and to offset to some degree the added costs necessary to keep older ships in service over the longer term. A key part of this effort centers on reducing the crew size needed to operate, maintain, and fight the ships. Importantly, because this effort can justifiably be seen as converting legacy Aegis/VLS ships into more capable I-LBNCs, the BNRAM should be funded out of more stable Ship Construction Navy (SCN) funds rather than the more volatile O&M accounts.

**— Third, immediately kick-start a clean-sheet competition to develop and design a family of next-generation Large Battle Network Combatants, with close oversight by the newly reconstituted Ship Characteristics Improvement Board (SCIB).** For nearly a century, the Navy's SCIB — a group of high-ranking DoN [Department of the Navy] officials — worked to balance desired warship warfighting requirements against their impact on a ship's final design and production costs. The primary reason why the Navy lost cost control over the DD-21/DD(X)/DDG-1000 was that just as the ship entered its design definition phase, the power of the Navy's SCIB was waning, replaced by a Joint requirements definition process with no fiscal checks and balances. One of the first things Admiral Mike Mullen, the current Chief of Naval Operations, did upon assuming his office was to reconstitute the Navy's SCIB. With a chance to start from a clean sheet of paper, naval design architects could leverage an additional decade of experience in the post-Cold War era to design an entirely new family of next-generation LBNCs, under the close oversight of the newly reconstituted SCIB. These new warships would have a common gas turbine or perhaps even a nuclear power plant that supplies enormous shipboard electrical generating capacity; common electric propulsion motors; common integrated power systems that distribute electric power to the ships' electric motors, combat systems, and weapons, as needed; and advanced automation to enable them to operate with relatively small crews. Their single common hulls, or network frames, should be large and easily produced, based on the best ideas of naval engineers, with an affordable degree of stealth. The network frames would be able to accept a range of open architecture battle network mission modules consisting of sensors and onboard and offboard weapons designed explicitly to support a battle network rapid capability improvement strategy. The cost-constrained goal for the combination of network frames and network mission modules would be to build new LBNCs at a rate of five every two years, allowing the complete transition from 84 Aegis/VLS I-LBNCs to 88 next-generation LBNCs in 35 years. The ships would be built under a profits-related-to-offer arrangement. While each of the two remaining surface combatant shipyards could count on building one LBNC per year, they would compete for an extra ship every other year. The yard with the lowest bid would be able to claim higher profit margins on the two LBNCs it would build until the next bi-annual competition. In this way, in addition to the natural cost savings due to learning curve efficiencies, the Navy would be able to spark continuous competition between the two building yards.

**— Starting in FY 2008, build a minimum of seven additional [Arleigh] Burke-class DDGs [i.e., DDG-51s] to help sustain the industrial base until the new LBNC is ready for production.** In effect, building one modified Burke each year between FYs 2008 and 2014 would replace the seven DDG-1000s in the current plan. For reasons that are detailed in the forthcoming report, the first four modified Burkes would be configured with the same Area Air Defense

Command Capability System (AADCCS) found on the Ticonderoga-class CGs. In addition, all seven ships would serve as active test beds for DDG improvements identified as possible candidates for further BNRAM backfits, or to test next-generation LBNC technologies. As such, the ships would serve much the same purpose as both the Forrest Sherman-class destroyers — which helped to bridge the shipbuilding gap between World War II combatants and Cold War combatants designed to battle jets, missiles, and high-speed submarines — and modified legacy combatants like the USS Gyatt, DDG-1, which helped to illuminate the way forward toward a new generation of BFC combatants. Provided all went as planned, Congress would authorize two of the next-generation LBNCs in FY 2015, split funded as in the current arrangement for the DDG-1000, giving each of the two remaining surface combatant construction yards one ship. The general fleet-wide transition from Aegis/VLS I-LBNCs to the new LBNC design would then begin in FY 2017, with three ships authorized after a bidding competition. Of course, if the design was not ready for production, additional Burkes could be built until it was.

**— Task each of the planning yards for CG and DDG modernization to design and implement a comprehensive follow-on maintenance regime to ensure all Aegis/VLS combatants are able to serve out the remainder of their 35-year service lives effectively.** The Navy's plan counts on every one of the 84 programmed Aegis/VLS combatants of completing 35 years of commissioned service. Yet, since the end of World War II, few surface combatants remain in commission beyond 25-30 years of service — even after receiving mid-life upgrades. Unless the BNRAM program includes a sustained maintenance regime beyond its mid-life HM&E, combat systems, and battle network upgrades and crew reduction measures, it is unlikely the ships will see their 35th year. The building shipyards might be the logical organizations to implement this new maintenance regime on the Navy's behalf. By establishing financial incentives that provide the yards with bonuses for every year a ship stays in service beyond 25 years, the Navy will maximize the probability that the ships will remain in service. As part of their efforts, the yards and the Navy should also solicit ideas for further ship improvements from vendors, and complete the trade studies for an expanded service life extension program (SLEP) of the existing ships, with a goal of extending their expected service lives to 40 years. This would provide a hedge should design work on the next-generation LBNC be delayed for any reason, or if a future maritime challenge spurs the need to rapidly expand the number of large combatants beyond the 88 included in the 313-ship Navy.[44]

[44] Robert Work, *Know When To Hold 'Em, Know When To Fold 'Em: Thinking About Navy Plans For The Future Surface Battle Line*, Washington, Center For Strategic and Budgetary Assessments, 2007. pp. 5-8. (CSBA Backgrounder, March 7, 2007).